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SOLAR/1024-79/02

Monthly Performance Report

LIVING SYSTEMS

FEBRUARY 1979

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U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT

LIVING SYSTEMS

FEBRUARY 1979

I. SYSTEM DESCRIPTION

The Living Systems site is a single-family residence in Davis, California. The home has approximately 1700 square feet of conditioned space. The solar energy system consists of two independently controlled systems: an active system for preheating domestic-hot-water (DHW) and a passive system for space heating the home.

The active solar DHW system has an array of flat-plate collectors with a gross area of 46 square feet. The array faces south at an angle of 45 degrees to the horizontal. Potable city water is the transfer medium used throughout the system. In the event of freezing and no insolation, the controller drains the water from the collectors. When water in the collector is sufficiently warmer than the water in the preheat storage tank, the controller starts the circulation between the preheat tank and the collector. The preheat tank holds 82 gallons of water which is supplied, on demand, to a conventional 20-gallon DHW tank. When the water preheated by solar energy is not hot enough to satisfy the hot water load, a natural gas burner in the DHW tank provides auxiliary energy for water heating. The system is shown schematically in Figure 1.

The passive solar space heating system is of the direct-gain type illustrated schematically in Figure 2. Incident solar energy is admitted to the building through both the large south-facing vertical windows (approximately 200 square feet) and the overhead skylight (approximately 80 square feet at 60 degrees from the horizontal). Manually-operated insulating curtains provide insulation during the night and sunless days for the south-facing collector windows. Manually-operated insulating shutters also provide night insulation for the skylight glazing and are aluminum coated to provide reflection to the space below when open. Solar energy is stored in steel tubes that contain approximately 3600 gallons of water. The tubes are painted blue and placed near the south window wall and under the skylight. Additional storage is provided by the 6-inch-thick concrete slab floor of the building which is covered by brown ceramic tile. Collected solar energy is distributed by natural convection, by conduction through the slab floor, and by radiation. Floor covering is minimal: linoleum in the kitchen and eating area and white shag rugs in two bedrooms. The building envelope is well insulated in order to ensure energy conservation, with R-19 insulation in the walls and R-30 insulation in the roof. The effective R-values of the windows are in the range of R-2 to R-10 (uncovered and covered with curtains and shutters). All glass surfaces are double-glazed with minimum window area in nonsouth-facing walls. Auxiliary space heating is provided by a gas-fired wall furnace which distributes the energy by natural convection. Additional auxiliary energy can be supplied from a wood-burning stove.

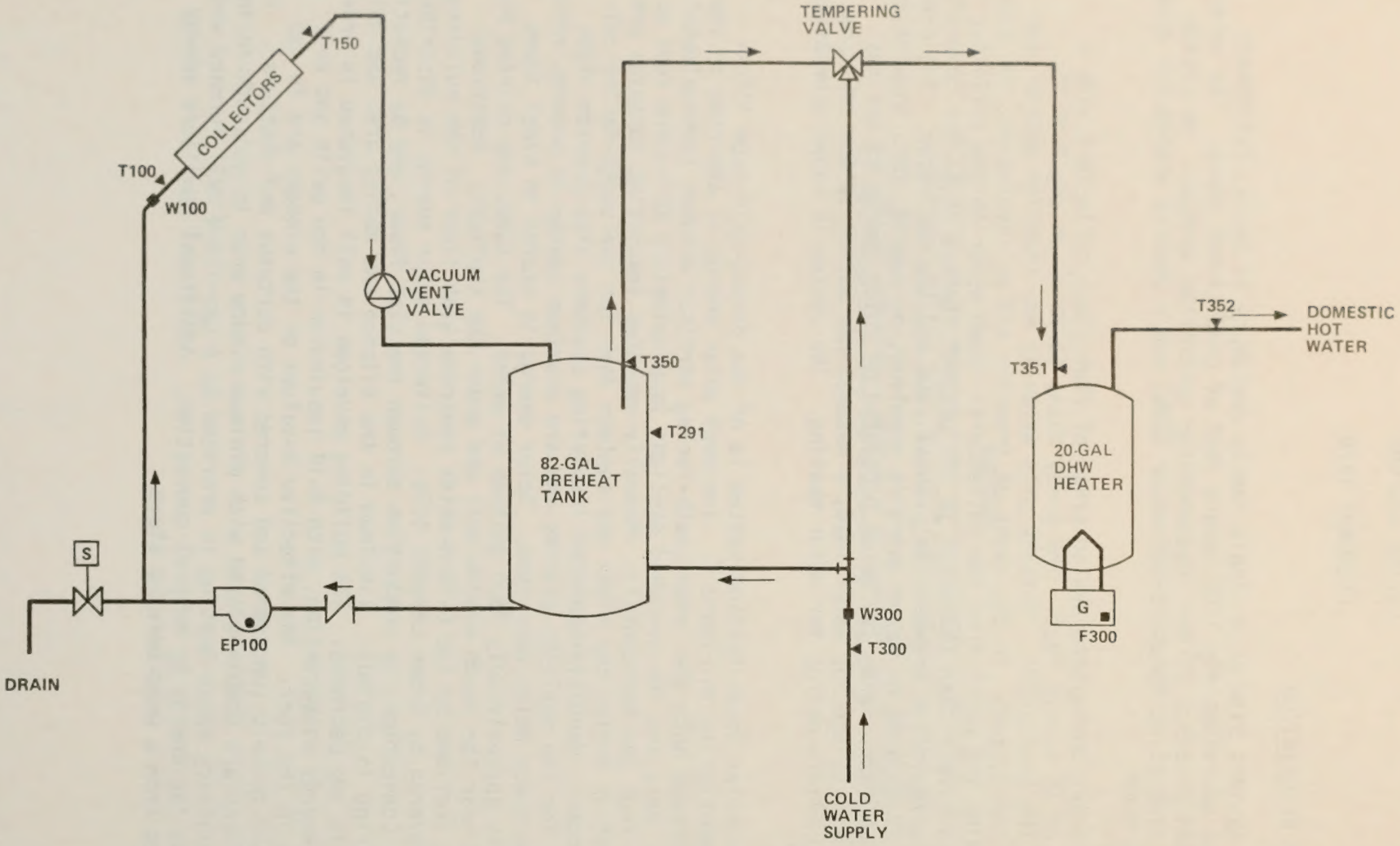

Figure 1. LIVING SYSTEMS ACTIVE SOLAR DOMESTIC HOT WATER SYSTEM SCHEMATIC

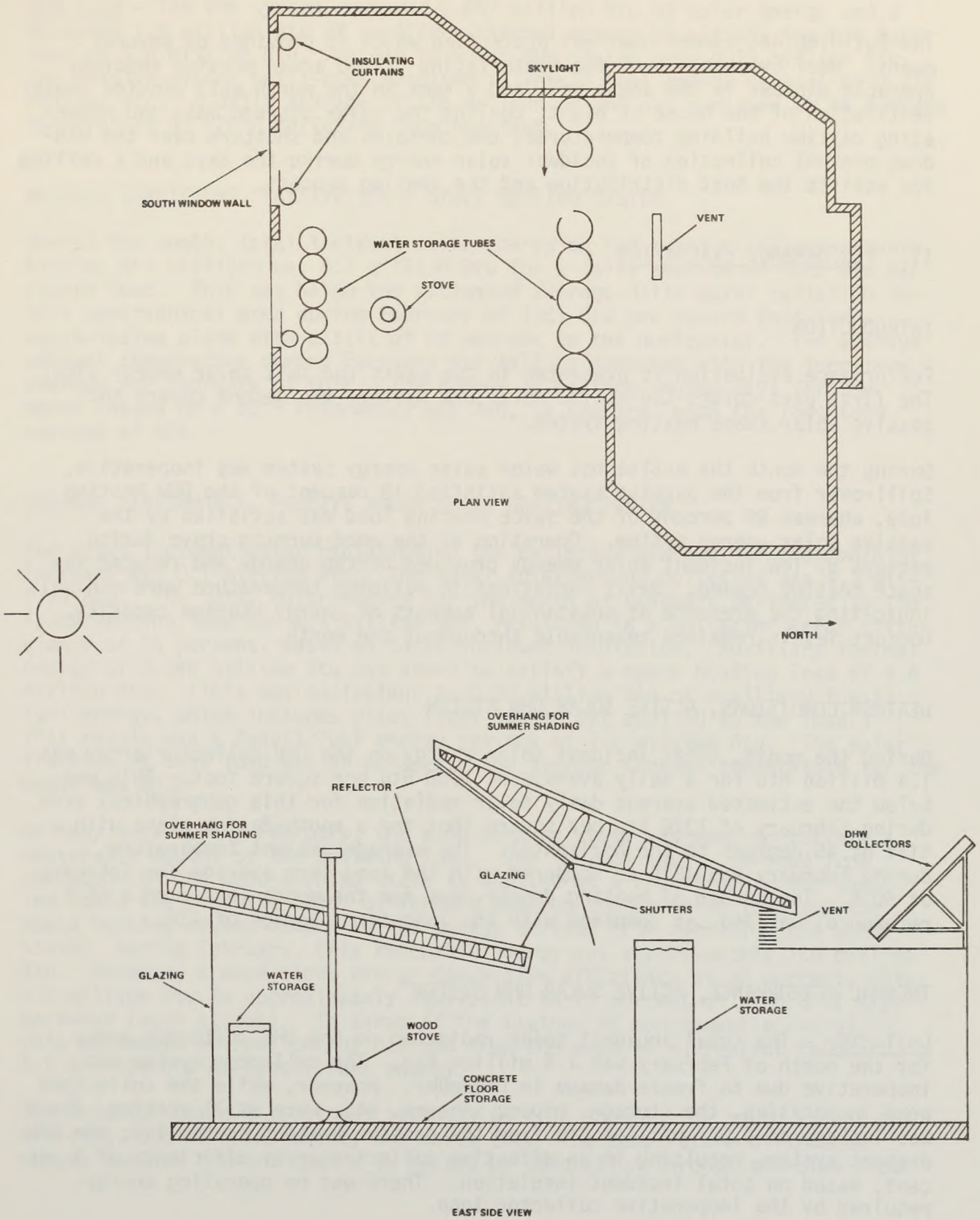

Figure 2. LIVING SYSTEMS PASSIVE SPACE HEATING SYSTEM

The building has summer overheat protection which is provided by several means: Roof overhangs over the south-facing glazed areas provide shading; operable windows in the south wall and a vent in the north wall provide cross-ventilation of the house at night, cooling the solar storage mass and moderating daytime building temperatures; the curtains and shutters over the windows prevent collection of incident solar energy during the day; and a ceiling fan assists the heat distribution and the venting process.

II. PERFORMANCE EVALUATION

INTRODUCTION

Performance evaluation is presented in two parts for this solar energy site: The first part covers the active solar DHW system; the second covers the passive solar space heating system.

During the month the active hot water solar energy system was inoperative. Spill-over from the passive system satisfied 18 percent of the DHW heating load, whereas 99 percent of the space heating load was satisfied by the passive solar energy system. Operation of the wood-burning stove during periods of low incident solar energy provided backup energy and reduced the space heating demand. Daily variations in building temperature were minimal, indicating the presence of substantial amounts of energy storage capacity. Comfort levels remained reasonable throughout the month.

WEATHER CONDITIONS, ACTIVE SOLAR DHW SYSTEM

During the month, total incident solar energy on the DHW collector array was 1.4 million Btu for a daily average of 1068 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during February of 1378 Btu per square foot for a south-facing plane with a tilt of 45 degrees to the horizontal. The average ambient temperature during February was 48°F as compared with the long-term average for February of 50°F. The number of heating degree-days for the month (based on a 65°F reference) was 466, as compared with the long-term average of 426.

THERMAL PERFORMANCE, ACTIVE SOLAR DHW SYSTEM

Collector - The total incident solar radiation on the DHW collector array for the month of February was 1.4 million Btu. The collector system was inoperative due to freeze damage in December. However, while the collectors were inoperative, the storage, pipes, sensors, etc. were still working, There was leakage of 0.047 million Btu from the passive heating system into the DHW preheat system, resulting in an effective collector array efficiency of 3 percent, based on total incident insolation. There was no operating energy required by the inoperative collector loop.

DHW Load - The DHW system consumed 0.047 million Btu of solar energy and a measured 1.6 million Btu of auxiliary thermal energy to satisfy the hot water load of 1.5 million Btu. Losses from the DHW system were 0.15 million Btu. The passive system spill-over resulted in fossil fuel energy savings of 0.078 million Btu. A daily average of 116 gallons of DHW was consumed at an average temperature of 120°F delivered from the tank.

WEATHER CONDITIONS, PASSIVE SOLAR SPACE HEATING SYSTEM

During the month, total incident solar energy on the passive collector south windows and skylight was 8.1 million Btu for a daily average of 1056 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during February of 1381 Btu per square foot for a south-facing plane with a tilt of 60 degrees to the horizontal. The average ambient temperature during February was 48°F as compared with the long-term average for February of 50°F. The number of heating degree-days for the month (based on a 65°F reference) was 466, as compared with the long-term average of 426.

THERMAL PERFORMANCE, PASSIVE SOLAR SPACE HEATING SYSTEM

The total incident solar radiation on the collector windows for the month of February was 8.1 million Btu. The total solar energy collected was 4.3 million Btu. The total solar energy for the month of February delivered to the space heating load was 4.3 million Btu, resulting in a collector array efficiency of 54 percent, based on total incident insolation. Auxiliary thermal energy of 0.046 million Btu was added to satisfy a space heating load of 4.4 million Btu. (This was equivalent to 0.50 million Btu of auxiliary fossil fuel energy, which includes pilot light losses not applied to the load.) This result was a fossil fuel energy savings of 7.2 million Btu. The solar fraction of this load was 99 percent. The average storage temperature for the month was 69°F

On many days during February, the wood-burning stove was used to satisfy a measurable amount of the building load. The thermal energy derived from operation of the wood-burning stove is applied as a reduction to the building load; that is, the major difference between the building load and the space heating system demand is the energy derived from operating the wood stove. During February, this renewable energy was approximately 1.0 million Btu. Assuming a wood stove energy conversion efficiency of 30 percent, this 1.0 million Btu is approximately equivalent to 11 percent of a cord of dry hardwood (such as oak). In terms of the savings of nonrenewable energy, this renewable thermal energy derived from the wood is equivalent to over 1.7 million Btu of fossil fuel energy.

The interior comfort level was given as 69°F in zone 1, the south end of the building, and 67°F in zone 2, the north end. The temperature difference occurs because comfort zone 2 is heated by conduction through the slab floor

and walls, and by convection and infiltration through the doors. The cooler temperatures in the bedrooms are not objectionable to the occupants.

OBSERVATIONS

During the month of February, the home owner became well adjusted to living in the passive home. The wood-burning stove was used for at least part of 15 days during the month. With the space heating load reduced by milder weather, operation of the reflective (and insulating) shutters and curtains was not as critical and the operational to incident solar energy went down. The last of the three shutters was repaired by the owner, but the curtains were not fully operational. The system was inoperative, but significant preheating occurred due to leakage from the passive system into the pipes and storage.

Computed comfort levels inside the building were reasonable during the entire month in both zones of the building. The comfort level in zone 2 was slightly lower than that of zone 1, due to the method of transferring heat to zone 2, with zone 1 being the primary collection and storage area of the house.

ENERGY SAVINGS

The solar energy systems yielded a total fossil fuel energy savings of 7.3 million Btu. The DHW system provided an estimated fossil fuel energy savings of 0.078 million Btu, while the space heating system contributed a fossil fuel energy savings of 7.2 million Btu.

III. ACTION STATUS

Repair of the DHW system is being negotiated by the owner.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

SITE/SYSTEM DESCRIPTION:
THE LIVING SYSTEMS SOLAR DOMESTIC HOT WATER SYSTEM PROVIDES PREHEAT TO THE BUILDING DOMESTIC HOT WATER SYSTEM . THIS ACTIVE SYSTEM USES FLAT PLATE COLLECTORS (46 SQ.FT.) TO HEAT WATER DIRECTLY IN A 82 GALLON STORAGE TANK. AUXILIARY HOT WATER ENERGY IS PROVIDED BY NATURAL GAS IN THE 20 GALLON HOT WATER HEATER.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	1.375	MILLION BTU
	29896	BTU/SQ.FT.
COLLECTED SOLAR ENERGY	0.000	MILLION BTU
	0	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	48	DEGREES F
AVERAGE BUILDING TEMPERATURE	65	DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.03	
ECSS OPERATING ENERGY	0.000	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	0.000	MILLION BTU
TOTAL ENERGY CONSUMED	2.675	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL	
LOAD	1.501	N.A.	N.A.	1.501	MILLION BTU
SOLAR FRACTION	18	N.A.	N.A.	18	PERCENT
SOLAR ENERGY USED	0.047	N.A.	N.A.	0.047	MILLION BTU
OPERATING ENERGY	N.A.	N.A.	N.A.	0.000	MILLION BTU
AUX. THERMAL ENERGY	1.604	N.A.	N.A.	1.604	MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A.	MILLION BTU
AUX. FOSSIL FUEL	2.674	N.A.	N.A.	2.674	MILLION BTU
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	0.000	MILLION BTU
FOSSIL SAVINGS	0.078	N.A.	N.A.	0.078	MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.561

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

SITE/SYSTEM DESCRIPTION:
THE LIVING SYSTEMS SOLAR DOMESTIC HOT WATER SYSTEM PROVIDES PREHEAT TO THE BUILDING DOMESTIC HOT WATER SYSTEM . THIS ACTIVE SYSTEM USES FLAT PLATE COLLECTORS (46 SQ.FT.) TO HEAT WATER DIRECTLY IN A 82 GALLON STORAGE TANK. AUXILIARY HOT WATER ENERGY IS PROVIDED BY NATURAL GAS IN THE 20 GALLON HOT WATER HEATER.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	1.451	GIGA JOULES
	339501	KJ/SQ.M.
COLLECTED SOLAR ENERGY	0.000	GIGA JOULES
	0	KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	9	DEGREES C
AVERAGE BUILDING TEMPERATURE	18	DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.03	
ECSS OPERATING ENERGY	0.000	GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	0.000	GIGA JOULES
TOTAL ENERGY CONSUMED	2.822	GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	1.583	N.A.	N.A.	1.583 GIGA JOULES
SOLAR FRACTION	18	N.A.	N.A.	18 PERCENT
SOLAR ENERGY USED	0.049	N.A.	N.A.	0.049 GIGA JOULES
OPERATING ENERGY	N.A.	N.A.	N.A.	0.000 GIGA JOULES
AUX. THERMAL ENG	1.692	N.A.	N.A.	1.692 GIGA JOULES
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. FOSSIL FUEL	2.821	N.A.	N.A.	2.821 GIGA JOULES
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	0.000 GIGA JOULES
FOSSIL SAVINGS	0.082	N.A.	N.A.	0.082 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.561

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.018	38	0.001	N	0.000	N	0.081
2	0.084	42	0.001	O	0.000	O	0.011
3	0.081	43	0.001	T	0.000	T	0.017
4	0.083	46	0.002		0.000		0.018
5	0.065	47	0.002	A	0.000	A	0.028
6	0.072	51	0.002	P	0.000	P	0.028
7	0.039	47	0.001	P	0.000	P	0.032
8	0.063	46	0.001	L	0.000	L	0.023
9	0.081	51	0.001	I	0.000	I	0.012
10	0.017	50	0.002	C	0.000	C	0.113
11	0.013	53	0.002	A	0.000	A	0.171
12	0.000	50	0.001	B	0.000	B	0.000
13	0.000	51	0.002	L	0.000	L	0.000
14	0.084	51	0.002	E	0.000	E	0.020
15	0.071	46	0.002		0.000		0.033
16	0.065	51	0.001		0.000		0.020
17	0.062	48	0.003		0.000		0.044
18	0.004	48	0.002		0.000		0.557
19	0.055	50	0.002		0.000		0.034
20	0.001	47	0.002		0.000		3.098
21	0.072	49	0.002		0.000		0.022
22	0.027	46	0.002		0.000		0.069
23	0.065	49	0.001		0.000		0.014
24	0.064	49	0.000		0.000		0.005
25	0.028	51	0.002		0.000		0.071
26	0.082	51	0.001		0.000		0.018
27	0.078	49	0.002		0.000		0.022
28	0.000	48	0.002		0.000		5.731
SUM	1.375	-	0.047	N.A.	0.000	N.A.	-
AVG	0.049	48	0.002	N.A.	0.000	N.A.	0.034
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.018	0.000	0.000	*	0.000
2	0.084	0.000	0.000	48	0.000
3	0.081	0.000	0.000	53	0.000
4	0.083	0.000	0.000	56	0.000
5	0.065	0.000	0.000	55	0.000
6	0.072	0.000	0.000	61	0.000
7	0.039	0.000	0.000	53	0.000
8	0.063	0.000	0.000	54	0.000
9	0.081	0.000	0.000	62	0.000
10	0.017	0.000	0.000	55	0.000
11	0.013	0.000	0.000	56	0.000
12	0.000	0.000	0.000	50	0.000
13	0.000	0.000	0.000	49	0.000
14	0.084	0.000	0.000	58	0.000
15	0.071	0.000	0.000	54	0.000
16	0.065	0.000	0.000	58	0.000
17	0.062	0.000	0.000	55	0.000
18	0.004	0.000	0.000	49	0.000
19	0.055	0.000	0.000	56	0.000
20	0.001	0.000	0.000	48	0.000
21	0.072	0.000	0.000	57	0.000
22	0.027	0.000	0.000	47	0.000
23	0.065	0.000	0.000	55	0.000
24	0.064	0.000	0.000	56	0.000
25	0.028	0.000	0.000	58	0.000
26	0.082	0.000	0.000	60	0.000
27	0.078	0.000	0.000	58	0.000
28	0.000	0.000	0.000	53	0.000
SUM	1.375	0.000	0.000	-	-
AVG	0.049	0.000	0.000	55	0.000
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.000	0.001	N	N	N
2	0.000	0.001	O	O	O
3	0.000	0.001	T	T	T
4	0.000	0.001			
5	0.000	0.001	A	A	A
6	0.000	0.001	P	P	P
7	0.000	0.001	P	P	P
8	0.000	0.001	L	L	L
9	0.000	0.000	I	I	I
10	0.000	0.001	C	C	C
11	0.000	0.002	A	A	A
12	0.000	0.001	B	B	B
13	0.000	0.002	L	L	L
14	0.000	0.001	E	E	E
15	0.000	0.002			
16	0.000	0.001			
17	0.000	0.002			
18	0.000	0.002			
19	0.000	0.001			
20	0.000	0.001			
21	0.000	0.001			
22	0.000	0.002			
23	0.000	0.001			
24	0.000	0.000			
25	0.000	0.002			
26	0.000	0.002			
27	0.000	0.002			
28	0.000	0.002			
SUM	0.000	0.033	N.A.	-	-
AVG	0.000	0.001	N.A.	N.A.	N.A.
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR.OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.050	9	0.001	N	0.052	N	0.087	N	0.002	64	120	97
2	0.032	6	0.001	O	0.040	O	0.066	O	0.002	61	113	66
3	0.089	4	0.001	T	0.101	T	0.169	T	0.002	61	117	217
4	0.066	17	0.002		0.063		0.105		0.003	63	126	128
5	0.041	58	0.002	A	0.023	A	0.039	A	0.003	62	115	91
6	0.080	3	0.002	P	0.080	P	0.134	P	0.003	63	116	168
7	0.035	4	0.001	P	0.048	P	0.079	P	0.002	62	114	78
8	0.046	5	0.001	L	0.046	L	0.076	L	0.002	62	112	113
9	0.041	4	0.001	I	0.056	I	0.094	I	0.002	63	119	81
10	0.091	3	0.002	C	0.080	C	0.134	C	0.003	65	124	197
11	0.059	6	0.002	A	0.063	A	0.106	A	0.004	64	122	156
12	0.053	7	0.001	B	0.062	B	0.104	B	0.002	64	125	106
13	0.060	4	0.002	L	0.073	L	0.121	L	0.004	64	127	126
14	0.042	5	0.002	E	0.049	E	0.081	E	0.003	63	122	96
15	0.068	41	0.002		0.033		0.055		0.004	63	115	161
16	0.042	8	0.001		0.057		0.095		0.002	63	124	83
17	0.075	5	0.003		0.077		0.129		0.005	64	124	152
18	0.070	8	0.002		0.083		0.138		0.004	65	119	173
19	0.068	10	0.002		0.074		0.123		0.003	62	129	121
20	0.055	4	0.002		0.061		0.102		0.003	62	123	114
21	0.041	8	0.002		0.048		0.079		0.003	62	121	84
22	0.043	6	0.002		0.051		0.085		0.003	62	111	114
23	0.029	4	0.001		0.039		0.065		0.001	63	119	59
24	0.008	2	0.000		0.035		0.059		0.001	62	127	16
25	0.073	23	0.002		0.062		0.104		0.003	61	118	161
26	0.038	77	0.001		0.148		0.246		0.002	62	122	80
27	0.048	98	0.002		0.000		0.000		0.003	61	121	92
28	0.058	100	0.002		0.000		0.000		0.003	61	121	127
SUM	1.501	-	0.047	N.A.	1.604	N.A.	2.674	N.A.	0.078	-	-	3257
AVG	0.054	18	0.002	N.A.	0.057	N.A.	0.095	N.A.	0.003	63	120	116
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	396	N	38	*	86	315	2
2	1826	C	42	48	68	206	10
3	1758	T	43	53	50	201	5
4	1812		46	56	69	187	4
5	1416	A	47	55	74	0	2
6	1559	P	51	61	75	*	4
7	841	P	47	53	87	*	3
8	1377	L	46	54	84	7	4
9	1758	I	51	62	79	0	1
10	363	C	50	55	93	9	4
11	281	A	53	56	93	0	2
12	0	B	50	50	98	33	4
13	0	L	51	49	100	34	12
14	1830	E	51	58	69	309	8
15	1533		46	54	84	7	6
16	1416		51	58	76	355	7
17	1353		48	55	75	8	4
18	91		48	49	96	20	8
19	1192		50	56	86	231	3
20	14		47	48	99	20	10
21	1575		49	57	80	347	7
22	596		46	47	92	11	12
23	1421		49	55	79	351	7
24	1400		49	56	80	0	1
25	598		51	58	81	337	3
26	1779		51	60	79	*	5
27	1703		49	58	75	347	3
28	7		48	53	93	359	9
SUM	29896	N.A.	-	-	-	-	-
AVG	1068	N.A.	48	55	82	358	5
NBS ID	Q001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

SITE/SYSTEM DESCRIPTION:
THE LIVING SYSTEMS PASSIVE SOLAR SPACE HEATING SYSTEM PROVIDES SPACE HEATING FOR A 1700 SQUARE FOOT SINGLE FAMILY DWELLING. THE LARGE SOUTH-FACING WINDOW WALL AND CLERESTORY SKYLIGHT PERMIT DIRECT WINTER SUN TO ENTER THE HOUSE. SOLAR ENERGY THERMAL STORAGE IS PROVIDED BY BOTH WATER FILLED TUBES AND THE CONCRETE SLAB FLOOR. MOVABLE SHUTTERS AND INSULATING CURTAINS PROVIDE CAPABILITY TO REDUCE NIGHT HEAT LOSSES. SUMMER OVERHEAT PROTECTION IS PROVIDED BY ROOF OVERHANGS AND BY NATURAL VENTILATION. AUXILIARY SPACE HEAT IS PROVIDED BY A NATURAL GAS FURNACE.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	8.070 MILLION BTU
	29560 BTU/SQ.FT.
COLLECTED SOLAR ENERGY	4.292 MILLION BTU
	15721 BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	48 DEGREES F
AVERAGE BUILDING TEMPERATURE	65 DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.54
ECSS OPERATING ENERGY	N.A. MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	N.A. MILLION BTU
TOTAL ENERGY CONSUMED	4.844 MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	4.391	N.A.	4.391 MILLION BTU
SOLAR FRACTION	N.A.	99	N.A.	99 PERCENT
SOLAR ENERGY USED	N.A.	4.345	N.A.	4.345 MILLION BTU
OPERATING ENERGY	N.A.	N.A.	N.A.	N.A. MILLION BTU
AUX. THERMAL ENERGY	N.A.	0.046	N.A.	0.046 MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. MILLION BTU
AUX. FOSSIL FUEL	N.A.	0.496	N.A.	0.496 MILLION BTU
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	N.A. MILLION BTU
FOSSIL SAVINGS	N.A.	7.242	N.A.	7.242 MILLION BTU

SYSTEM PERFORMANCE FACTOR: 8.856

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

SITE/SYSTEM DESCRIPTION:
THE LIVING SYSTEMS PASSIVE SOLAR SPACE HEATING SYSTEM PROVIDES SPACE HEATING FOR A 1700 SQUARE FOOT SINGLE FAMILY DWELLING. THE LARGE SOUTH-FACING WINDOW WALL AND CLERESTORY SKYLIGHT PERMIT DIRECT WINTER SUN TO ENTER THE HOUSE. SOLAR ENERGY THERMAL STORAGE IS PROVIDED BY BOTH WATER FILLED TUBES AND THE CONCRETE SLAB FLOOR. MOVABLE SHUTTERS AND INSULATING CURTAINS PROVIDE CAPABILITY TO REDUCE NIGHT HEAT LOSSES. SUMMER OVERHEAT PROTECTION IS PROVIDED BY ROOF OVERHANGS AND BY NATURAL VENTILATION. AUXILIARY SPACE HEAT IS PROVIDED BY A NATURAL GAS FURNACE.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	8.514	GIGA JOULES
	335686	KJ/SQ.M.
COLLECTED SOLAR ENERGY	4.528	GIGA JOULES
	178525	KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	9	DEGREES C
AVERAGE BUILDING TEMPERATURE	18	DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.54	
ECSS OPERATING ENERGY	N.A.	GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	N.A.	GIGA JOULES
TOTAL ENERGY CONSUMED	5.110	GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	4.633	N.A.	4.633 GIGA JOULES
SOLAR FRACTION	N.A.	99	N.A.	99 PERCENT
SOLAR ENERGY USED	N.A.	4.584	N.A.	4.584 GIGA JOULES
OPERATING ENERGY	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. THERMAL ENG	N.A.	0.048	N.A.	0.048 GIGA JOULES
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. FOSSIL FUEL	N.A.	0.523	N.A.	0.523 GIGA JOULES
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	N.A. GIGA JOULES
FOSSIL SAVINGS	N.A.	7.640	N.A.	7.640 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 8.856

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.110	0.078	N	*	N
2	0.505	0.385	O	48	O
3	0.486	0.427	T	53	T
4	0.500	0.350		56	
5	0.388	0.242	A	55	A
6	0.431	0.327	P	61	P
7	0.220	0.028	P	53	P
8	0.376	0.187	L	54	L
9	0.483	0.425	I	62	I
10	0.088	0.080	C	55	C
11	0.067	0.027	A	56	A
12	0.000	0.000	B	50	B
13	0.000	0.000	L	49	L
14	0.498	0.370	E	58	E
15	0.417	0.166		54	
16	0.389	0.181		58	
17	0.368	0.212		55	
18	0.020	0.005		49	
19	0.315	0.148		56	
20	0.002	0.001		48	
21	0.424	0.112		57	
22	0.154	0.036		47	
23	0.380	0.287		55	
24	0.374	0.088		56	
25	0.148	0.027		58	
26	0.475	0.249		60	
27	0.451	0.005		58	
28	0.001	0.000		53	
SUM	8.070	4.444	4.292	-	-
AVG	0.288	0.159	N.A.	55	N.A.
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.133	96	0.128	N	0.005	N	0.026	N	0.213	61	38
2	0.174	100	0.174	O	0.000	O	0.020	O	0.290	63	42
3	0.186	100	0.186	T	0.000	T	0.018	T	0.310	63	43
4	0.213	99	0.212		0.002		0.015		0.353	64	46
5	0.199	99	0.197	A	0.002	A	0.017	A	0.328	65	47
6	0.187	99	0.185	P	0.003	P	0.018	P	0.308	66	51
7	0.191	98	0.187	P	0.004	P	0.020	P	0.312	64	47
8	0.195	98	0.191	L	0.004	L	0.022	L	0.319	64	46
9	0.174	100	0.174	I	0.000	I	0.015	I	0.290	67	51
10	0.163	97	0.157	C	0.005	C	0.022	C	0.262	65	50
11	0.122	97	0.118	A	0.004	A	0.021	A	0.196	66	53
12	0.083	96	0.080	B	0.003	B	0.019	B	0.133	66	50
13	0.107	96	0.103	L	0.004	L	0.022	L	0.171	65	51
14	0.134	98	0.132	E	0.002	E	0.020	E	0.220	68	51
15	0.191	98	0.187		0.005		0.023		0.311	66	46
16	0.172	99	0.171		0.002		0.018		0.284	67	51
17	0.131	99	0.129		0.002		0.020		0.215	66	48
18	0.180	100	0.180		0.000		0.001		0.300	64	48
19	0.154	100	0.154		0.000		0.000		0.257	65	50
20	0.166	100	0.166		0.000		0.000		0.277	62	47
21	0.085	100	0.085		0.000		0.022		0.142	66	49
22	0.186	100	0.186		0.000		0.022		0.310	62	46
23	0.113	100	0.113		0.000		0.023		0.189	65	49
24	0.156	99	0.154		0.002		0.021		0.257	64	49
25	0.129	100	0.129		0.000		0.022		0.215	64	51
26	0.147	100	0.147		0.000		0.021		0.246	65	51
27	0.155	100	0.155		0.000		0.017		0.259	64	49
28	0.165	100	0.165		0.000		0.017		0.274	63	48
SUM	4.391	-	4.345	N.A.	0.046	N.A.	0.496	N.A.	7.242	-	-
AVG	0.157	99	0.155	N.A.	0.002	N.A.	0.018	N.A.	0.259	65	48
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

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N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	404	N	38	*	86	315	2
2	1850	O	42	48	68	206	10
3	1782	T	43	53	50	201	5
4	1831		46	56	69	187	4
5	1420	A	47	55	74	0	2
6	1579	P	51	61	75	*	4
7	807	P	47	53	87	*	3
8	1378	L	46	54	84	7	4
9	1768	I	51	62	79	0	1
10	321	C	50	55	93	9	4
11	244	A	53	56	93	0	2
12	0	B	50	50	98	33	4
13	0	L	51	49	100	34	12
14	1825	E	51	58	69	309	8
15	1528		46	54	84	7	6
16	1425		51	58	76	355	7
17	1347		48	55	75	8	4
18	72		48	49	96	20	8
19	1155		50	56	86	231	3
20	8		47	48	99	20	10
21	1554		49	57	80	347	7
22	563		46	47	92	11	12
23	1393		49	55	79	351	7
24	1369		49	56	80	0	1
25	543		51	58	81	337	3
26	1739		51	60	79	*	5
27	1653		49	58	75	347	3
28	2		48	53	93	359	9
SUM	29560	N.A.	-	-	-	-	-
AVG	1056	N.A.	48	55	82	358	5
NBS ID	0001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
PASSIVE SPACE HEATING

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MON	SPACE HEATING LOAD MILLION BTU	SOLAR ENERGY USED MILLION BTU	CHANGE IN STORE ENERGY MILLION BTU	AVERAGE STORAGE TEMP DEG F	DIRECT SOLAR UTIL EFFIC	AUX THERMAL USED MILLION BTU	BLDG TEMP DEG F	AMB TEMP DEG F	WIND AVG SPEED MPH	WIND AVG DIR DEG	SOLA FR LOAD PER CENT
1	0.132	0.127	0.053	68.1	1.161	0.004	61	38	2.5	315	96
2	0.173	0.173	0.087	69.9	0.344	0.000	63	42	10.5	206	100
3	0.186	0.186	0.064	71.2	0.383	0.000	63	43	5.2	201	100
4	0.213	0.211	0.046	70.7	0.423	0.001	64	46	3.9	187	99
5	0.198	0.196	-0.033	70.3	0.507	0.002	65	47	1.7	0	99
6	0.187	0.184	0.088	70.6	0.428	0.002	66	51	3.9	*	99
7	0.190	0.187	-0.128	69.4	0.850	0.003	64	47	3.4	*	98
8	0.195	0.191	-0.006	68.2	0.509	0.004	64	46	3.9	7	98
9	0.173	0.173	0.135	69.8	0.360	0.000	67	51	0.9	0	100
10	0.162	0.157	-0.086	69.5	1.796	0.005	65	50	3.9	9	97
11	0.121	0.117	-0.050	68.3	1.764	0.004	66	53	1.8	0	97
12	0.082	0.079	0.057	68.6	0.000	0.003	66	50	4.0	33	96
13	0.106	0.102	-0.054	69.2	0.000	0.004	65	51	11.6	34	96
14	0.133	0.131	0.131	71.6	0.265	0.002	68	51	8.3	309	98
15	0.191	0.186	-0.038	70.8	0.447	0.004	66	46	5.9	7	98
16	0.172	0.170	-0.016	70.2	0.439	0.001	67	51	6.6	355	99
17	0.130	0.129	0.004	70.7	0.351	0.001	66	48	4.3	8	99
18	0.180	0.180	-0.134	68.6	9.135	0.000	64	48	7.9	20	100
19	0.154	0.154	0.030	67.4	0.490	0.000	65	50	2.7	231	100
20	0.166	0.166	-0.090	66.7	72.549	0.000	62	47	10.0	20	100
21	0.085	0.085	0.050	67.7	0.201	0.000	66	49	7.4	347	100
22	0.186	0.186	-0.100	66.5	1.212	0.000	62	46	11.5	11	100
23	0.113	0.113	0.111	68.3	0.298	0.000	65	49	6.8	351	100
24	0.155	0.153	-0.042	67.6	0.412	0.001	64	49	1.5	0	99
25	0.129	0.129	-0.037	66.6	0.870	0.000	64	51	3.3	337	100
26	0.147	0.147	0.046	67.2	0.310	0.000	65	51	5.3	*	100
27	0.155	0.155	-0.031	66.8	0.344	0.000	64	49	3.1	347	100
28	0.164	0.164	-0.105	65.7	326.592	0.000	63	48	8.8	359	100
SUM	4.391	4.344	-0.053	-	-	0.045	-	-	-	-	-
AVG	0.156	0.155	-0.001	68.8	0.538	0.001	65	48	5.4	358	99
NBS	Q402	Q400	Q202			Q401	N405	N113	N114	N115	N400

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
PASSIVE SYSTEM ENVIRONMENT

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/02
REPORT PERIOD: FEBRUARY,1979

DAY OF MON	BUILDING COMFORT ZONE 1	BLDG COMF ZONE 2	BUILDING TEMP MIDNIGHT DEG F	BUILDING TEMP 6 AM DEG F	BUILDING TEMP NOON DEG F	BUILDING TEMP 6 PM DEG F	INTERIOR RELATIVE HUMIDITY PERCENT	AMB TEMP DEG F	DAYTIME AMB TEMP DEG F	INCIDENT SOLAR ENERGY MILLION BTU	AVG STOR TEMP DEG F
1	68	63	62	59	*	63	30	38	*	0.110	68
2	70	65	61	60	64	64	27	42	48	0.505	70
3	71	66	63	59	65	67	25	43	53	0.486	71
4	70	67	66	59	65	69	29	46	56	0.500	71
5	70	67	65	61	64	68	33	47	55	0.388	70
6	71	68	67	61	66	69	34	51	61	0.431	71
7	69	67	64	63	62	66	36	47	53	0.220	69
8	68	67	64	61	63	68	37	46	54	0.376	68
9	70	68	67	61	68	71	36	51	62	0.483	70
10	69	68	67	63	64	67	40	50	55	0.088	70
11	68	68	66	65	65	67	44	53	56	0.067	68
12	69	67	67	64	66	67	41	50	50	0.000	69
13	69	67	67	65	64	63	42	51	49	0.000	69
14	72	69	65	65	68	71	39	51	58	0.498	72
15	70	68	66	61	68	68	37	46	54	0.417	71
16	70	68	66	64	68	69	40	51	58	0.389	70
17	71	68	65	63	67	67	37	48	55	0.368	71
18	68	67	64	64	64	64	40	48	49	0.020	69
19	68	67	65	62	63	68	43	50	56	0.315	67
20	66	65	64	63	61	61	42	47	48	0.002	67
21	68	66	65	64	67	68	41	49	57	0.424	68
22	66	65	63	62	61	63	41	46	47	0.154	66
23	69	66	65	62	67	68	39	49	55	0.380	68
24	68	66	64	62	64	67	42	49	56	0.374	68
25	66	66	65	62	65	66	43	51	58	0.148	67
26	67	66	65	63	66	68	42	51	60	0.475	67
27	67	66	65	61	65	68	42	49	58	0.451	67
28	65	65	62	62	62	63	43	48	53	0.001	66
SUM	-	-	-	-	-	-	-	-	-	8.070	-
AVG	69	67	65	62	65	67	38	48	55	0.288	69
NBS								N113			

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

*U.S. GOVERNMENT PRINTING OFFICE: 1979-640-189/4101. Region 4.

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